Korea, Y. N. KIM, *Flow-Noise Company, Korea,* Computational Aeroacoustics (CAA) deals about capturing radiated acoustic quantities generated from flow fluctuations numerically. In general, the amplitude of acoustics is less than 4^{th} order of the flow. Therefore, a higher order scheme, such as compact scheme, is employed to capture the acoustic and flow at the same time. To minimize the numerical phase error in the radiated acoustics, the coefficients of the high order scheme are optimized to have minimum dispersion error. The high order optimized compact schemes are applied in the acoustic propagation of the cavity tone from the subsonic flow and screech tone from the supersonic flow. Cavity tone and Screech tone are generated due to the feedback between flow and acoustic wave. In this paper, the feedback phenomena are calculated numerically to obtain detail information of flow and acoustic wave to explain the mechanism including the phase shift and mode change. The detail calculation is used for the time required for the feedback and phase problem. It is found that no phase shift is required if we examine the time required carefully. The phase shift of cavity tone is depending on the position of the acoustic source and the mode of the tone. Rossiter's formula for the cavity tone used for quick explanation of mode from experimental data needs to be reexamined. Screech tone is also calculated with the high order high resolution scheme. The tone is due to the feedback between the flow and acoustic and the numerical results are compared with experimental data for the Mach number of mode change, which shows reasonable agreements. Also the transient characteristics of axisymmetric screech tones are investigated and three dimensional screech tone is also simulated briefly. Even limited physical and numerical conditions in calculation because of high order high resolution scheme, the phase problem can be clearly explained for the cavity in the range of laminar cases and the mode change Mach number is reasonably predicted with the inviscid assumption for the axisymmetric supersonic jet. Additionally, other effective methods for numerical analysis of incompressible flow noise are addressed and discussed.

IL-6. PROGRESS IN THE DEVELOPMENT AND APPLICATION OF LATTICE BOLTZMANN METHOD

C. SHU, Y. T. CHEW, X. D. NIU, Y. PENG, H. W. ZHENG and N. Y. LIU, *Department of Mechanical Engineering, National University of Singapore, Singapore,* As an alternative computational fluid dynamics approach, lattice Boltzmann method (LBM) receives more and more attention in recent years. LBM is a particle-based approach, which does not involve the solution of partial differential equations and their resultant algebraic equations. Thus, its implementation and coding are very simple. Currently, LBM has been widely applied to simulate various fluid flow problems. This paper will report the progress in the development and application of LBM by the group of National University of Singapore. In the development of lattice Boltzmann model, we developed a general platform for the users to design their own lattice velocity model and associated equilibrium distribution functions. In the application of LBM, we developed the Taylor series expansion- and least-square-based lattice Boltzmann method (TLLBM), simplified thermal lattice Boltzmann model, lattice kinetic scheme and the fractional step lattice Boltzmann model. These models can effectively simulate isothermal and thermal flows with complex geometry and at high Reynolds numbers. In the application of LBM for simulation of micro flows, we proposed a new relationship between relaxation parameter τ and Knudsen number, and the diffuse-scattering boundary condition (DSBC) from the kinetic theory. In the application of LBM for simulation of multiphase flows, we presented a new interface capturing lattice Boltzmann model, which can recover the Cahn-Hilliard equation up to the second order of accuracy. The proposed model can well simulate multiphase flows with large density ratio. Recently, we developed a new lattice Boltzmann model for simulation of compressible flows with strong shock waves. The equilibrium distribution functions and associated lattice velocity model are developed from satisfaction of conservation laws in physics. The paper will also address our latest development of lattice Boltzmann-immersed boundary velocity correction method (LB-IBVCM), which can accurately satisfy the non-slip condition on the wall.

IL-7. HYDRAULIC MODELING OF SOIL EROSION

Q. Q. LIU, *IMECH CAS, China,* The prediction and estimate of soil erosion is fundamental important for understanding the effect of the spatial heterogeneity of underlying surfaces and preventing ecological environment deterioration. Since soil and rainfall characteristics substantially vary in different regions, the empirical models do not reflect the overall effect of various factors. Accordingly, there seems to be a shift in emphasis from the empirical approach to the process-based dynamic approach to soil erosion. The water erosion is mainly caused by natural rainfall, and is such a process that sheet flow generated during rainfall scours the soil surface. The erosion process can be divided into three basic dynamics processes, including the process of runoff generation caused by rainfall, the process of sediment yield on hillslope by overland flow, and the process of runoff concentration and sediment transport on watersheds. A process-based soil erosion model was developed according to the characteristics of soil erosion on the Loess Plateau. The proposed model includes three component models: the rainfall-runoff sub-model on hillslopes, the soil erosion sub-model on hillslopes and the runoff concentration and sediment transport sub-model on watersheds. The kinematic wave approximation combining the infiltration excess runoff was applied to describe the runoff yield process. Interrill erosion and rill erosion are two basic types of soil erosion on rural hillslopes. Therefore, the soil erosion sub-model includes these two parts: interrill erosion and rill erosion. A two-dimensional hydrodynamics model was employed to describe the runoff concentration and sediment transport. The erosion model on hillslopes was verified by laboratory experiments, and overall, good agreements were found between simulation results and experimental observations. Rainfall and slope characteristics affecting runoff generation and soil erosion on hillslopes were analyzed by using the proposed model. The primary hydraulic characteristics of the runoff generation, such as unit discharge, runoff depth, flow velocity, shear stress and ratio of runoff generation are obtained and analyzed. Especially, the slope length and gradient play important roles in the processes of soil erosion on hillslopes. The modeling results show that the slope length and gradient, time distribution rainfall, and distribution of rills have varying influence on soil erosion. Erosion rate increases nonlinearly with increase in the slope length; a long slope length leads to more serious erosion. The effect of the slope gradient on soil erosion can be both positive and negative. Thus, there exists a critical slope gradient for soil erosion, which is about 25^{o} for the accumulated erosion. Applying the proposed model to a typical small catchment in the loess plateau area of China, the runoff and sediment yield process was estimated, which exhibited a good agreement between predicted results and observation. It also demonstrated that the proposed model is capable of adequately simulating the process of runoff yield and soil erosion on small watersheds.

IL-8. SIMULATION, PREDICTION AND EXPERIMENT ON WINDBLOWN SAND MOVEMENT AND AEOLIAN GEOMORPHOLOGY

X. J. ZHENG, *Key Laboratory of Mechanics on Western Disaster and Environment, Lanzhou University, China,* In the evolution processes of wind blown sand movement and aeolian geomorphology, it always contains some complex behaviors, for example, the nonlinear character of turbulence and attractors, the stochastic character of wind gust, liftoff and movement of sand, the interaction among wind field, sand movement, electric field in wind blown sand flux and thermal diffusion, multi-scale character from sand ripple to dune, which deserve to be paid attention by mechanical researchers. In this paper, we introduce the recent works of our research group in Lanzhou University, China on the measurement, modeling and simulation of wind blown sand movement and aeolian geomorphology in detail.

10:30 ~ 11:50 (Room 101)

Reacting Flows (I)

Session Chair : Prof. I. Lee, Pusan Univ/Korea

T-1A-1. NUMERICAL SIMULATION OF A 200 MW INDUSTRIAL BOILER

M. D. EMAMI*, Isfahan University of Technology, Isfahan, Iran*, S. POURARIAN, *Nargan Engineering Co., Tehran, Iran*, H. AFSHIN, *Sharif University of Technology, Tehran, Iran*, S. ZIAEI-RAD, *Isfahan University of Technology, Isfahan, Iran,* Numerical simulation of a gaseous-fuelled boiler of a power plant has been performed, using Favre-averaged equations of mass, momentum, energy, turbulent kinetic energy and its dissipation, the transport equations of the mixture fraction and its variance, and the radiation transfer equation. The mixture fraction concept is used to model combustion, and the turbulence-combustion interaction is taken into account by the use of a presumed probability density function. The computer code is a finite volume based code, with collocated grids and SIMPLEC algorithm. Higher-order convection schemes and second-order diffusion schemes are used for discretization of the governing partial differential equations. The purpose was to find out the reason for overheating the super-heater tubes of the boiler, and proposing a remedy for the problem. Results of the base case show hot regions in the aerodynamic nose of the boiler, which are undesirable because of proximity of super-heater tubes to this area. The Nitrogen mass fraction contours, which are measures of the air distribution, also reveal non-uniformity in air